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ABSTRACT

This paper defines a schema as a memory structure representing a general concept and its framework of associated concepts, and identifies the three processes by which learning can occur in individuals whose memories are schema-based, i.e., accretion, tuning, and restructuring. Ways in which schema might influence instructional design are then discussed: (1) identification of the pre-existing schema before designing instruction; (2) organization, provision of cues, and elaboration to aid accretion; (3) elaboration and practice with a variety of examples to aid schema tuning; and (4) discovery learning through analogy or problem-solving restructuring by schema induction. Ten references are listed. (MES)

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The Idea of the Schema

(Annual Meeting, AECT, Atlanta, March 1, 1987)

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Historically speaking, the idea of the schema as a mental entity was given prominence by the work of Sir Frederick Bartlett of Cambridge University, reported in his book entitled Remembering. Bartlett obtained records of the memories people had for a story called The War of the Ghosts, about two young men who set out to hunt seals. Not only did he find that details were forgotten, but also that details were added, in such remembrances. For example, as part of the fight the two men got into, they are remembered as shooting with bows and arrows; this detail was not a part of the actual story. From the evidence of this study, Bartlett concluded that the basic entity being retained in memory was a schema, a kind of general conception of the story and its plot, into which particular details were fitted. The schema was a kind of conventional representation of the story--details that were compatible with this representation were recaptured, while others were actually constructed to fit the conventions. This general representation was what was remembered, and which Bartlett called a schema.

Although at the time this idea didn't seem to fit with the prevailing trends in memory research, it really was quite an important notion. By this later time, schema has taken its place as a key concept in various cognitive theories of learning and memory. Its applicability has been greatly expanded. For example, besides schemas for stories (Sulin & Dooling, 1974), expository passages about how things work (Bransford & Johnson, 1972), schemas are also used in organizing memories of pictures (Mandler & Johnson, 1976), and in the form of scripts, as representation of typical lifetime events like going to a restaurant (Schank & Abelson, 1977). Generally, schemas have been conceived as providing organization for declarative knowledge (verbal information), but J. R. Anderson (1983) argues strongly that this conception must not be allowed to blur the distiction between such knowledge and procedural knowledge, or what he calls production systems (intellectual skills). A production system may be viewed as a schema, but its important properties are as a procedure (or intellectual skill), in which the sequence is condition--action, and one cannot go the other

way.

Definition

Since there have been all of these variations in the employment of the schema idea, is it possible to determine a definition that applies to all? Of course, people who try to interpret research findings, like those who write elementary texts, try to do this all the time. One person who has formulated the characteristics of schema is Richard Anderson (1984). His view is that comprehension of prose is a matter of "activating or constructing a schema that provides a coherent explanation of objects and events mentioned in a discourse." (p. 247). I paraphrase these characteristics as follows:

1. A schema provides a framework for taking in new information, including "slots" for thematic ideas. (Restaruant schema - waiter).

2. A schema helps the selective allocation of attention. (Where to pay close attention).

3. A schema provides a basis for making inferences. (Go beyond the literal).

4. A schema makes possible efficient memory search. (Recalling events of presidential election campaigns).

5. A schema facilitates summarizing.

6. A schema permits learner to generate hypotheses about missing information.

A schema, then, may be defined as a memory struture representing a general concept and its framework of associated concepts; the framework provides for the linking of particular details at locations (called "slots") that are established by experience with the general concept. Obviously, this definition can encompass such a schema as "going to a restaurant," and provide for the linking of particular events or items of the menu. The definition can apply to a general concept like "bagpipe" to make possible the interpretation of such a sentence as "The notes were sour because the seams split" (Bransford & McCarrell, 1974). And it can equally well apply to the kind of structures that are at work in the understanding of word problems in arithmetic, or to the structure of a geometric proof.

Schemas and Learning

According to Rumelhart (1980), and Rumelhart and Norman

(1978), there are three ways that learning can occur in individuals whose memory is schema-based. The first is called accretion, and it means simply the acquiring of new detailed facts that fit in with the structure already present.

A second process is called tuning, which means a kind of evolving change to bring the general concept in line with increased experience. New examples bring about elaboration and refinement of the concept and its structure in memory.

The third sort of change is called restructuring, and involves the creation of a new schema. This may be done (1) by copying an old one with a few modifications, "learning by analogy." A second way is called schema induction. In this case the spatio-temporal configuration becomes the basis for a new schema, without reference to analogy of a pre-existing schema. The notion of schema induction is indeed an intriguing one. Are we as human beings capable of generalizing the spacial framework of schemas without reference to their content, and by this means to invent new schemas? It may be that this is "mind boggling" in a literal sense.

Applications

The idea of the schema has been applied to the design of research in reading, writing, and arithmetic. In each of these fields, the concept of schema helps to explain the nature of the learning process involved. Can the notion of schema be used to advantage in the design of instruction? It would seem that it could be. If what is happening in learning is accretion to the schema, or tuning, or restructuring, surely these ideas should have some effect on how instruction is designed.

Here are a few ways that the schema idea might influence the design of lessons with serious learning objectives:

1. Before designing instruction for the new content to be learned, identify the pre-existing schema to which accretion or tuning is to be applied. In other words, look first for prerequisites and for the larger meaningful context into which the new learning will be fitted. As a first step in instruction, make sure that this prior knowledge--this schema--is retrieved to working memory. This is the function of the advance organizer, or the pre-test, of the set of adjunct questions, or even of the simple reminder; whatever precedes the body of the instruction itself.

2. Instruction for schema accretion. The key ideas about learning new "facts" to add to an existing structure would appear to be (a) organize, (b) provide cues for retrieval, and (c)

elaborate. These three have somewhat overlapping meanings. Learning the names of the United States may be aided by the organization of a spatial map. Such a map also provides cues for retrieval, when stored as an image. The names of states may be linked to other elaborative facts, such as the association of Vermont with the Green Mountains, or Virginia with Patrick Henry and his well-known speech. In serving these purposes, instruction may use a variety of modes, such as pictures, verbal suggestions, outlines, inserted questions, tables, and others.

3. Instruction for schema tuning. Here we are dealing with an initial crude or incomplete schema, and the instruction is designed to make the schema more accurate and complete. In the case of an intellectual skill, it would seem that the primary way of accomplishing this end is by means of practice on a variety of examples. Thus a simple schema for adding fractions such as 1/2 and 1/3 must be practiced in examples that include the addition of 5/13 plus 7/37, and also the addition of such fractions as a/b plus b/c. For verbal information (declarative knowledge), tuning a schema may be a matter of adding linked facts, but also of acquiring the interrelationships these facts have to the basic structure, so that the schema itself becomes at once more complete and more complex. What one learns in the fifth grade about the operations of the U.S. Congress is subject to tuning by the later learning that occurs by following current events, and also by later courses in American Government. The key ideas for tuning, then, are (a) variety of examples, and also (b) elaboration.

4. Instruction for schema induction. It would appear that if instruction has the purpose of schema restructuring, or schema induction, this is the place for "discovery learning." In simple cases, the learner can discover a new schema when instruction suggests an analogy. The relation between volume of a container and the pressure on its surfaces can be acquired (or induced) by using the analogy of small particles (molecules) in constant random motion. More complex analogies can be employed to induce schemas that underlie understanding of the atom and its nucleus. More rigorous uses of "discovery" may be used in complex problem-solving situations, which result in the formation of schemas identified by conceptual structures that I have called higher-order rules. Such rules are typically tied in content to the substance of the problem itself. For example, in Katona's matchstick problems, the learner may acquire the higher-order rule of "opening up the figure by eliminating shared sides," and thereby be able to solve any number of new matchstick problems. It is not at all evident that the schema concept, as such, helps us to see how to get from that point to "becoming a better problem-solver."

It seems clear, then, that the notion of schema does have some implications for understanding human learning, and therefore some useful implications for the design of instruction. As the concept becomes more precise in theory, perhaps it will yield an increased number of ideas for instruction. In the meantime, it appears to be quite compatible with other models of instruction, and to serve as a useful guide to design.

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